SMALL-POX

JAMES WALLACE

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SMALL-POX.

SMALL-POX:

HOW IT IS SPREAD AND HOW IT MAY BE PREVENTED.

DRAWN FROM THE FACTS OF THE WARRINGTON SMALL-POX EPIDEMIC OF 1892-93.

BY

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PREFACE.

At a time like the present, when small-pox has declared itself in many quarters, it is well to know what lessons are to be derived from former epidemics, more especially from any epidemic which has been thoroughly investigated in all its bearings. Such an epidemic was that which occurred in Warrington in 1892-93. It was made a subject of special enquiry in connection with the Royal Commission on Vaccination, by Dr. T. D. Savill, Medical Officer to the Commission. His report is a very complete one, giving statistics regarding the epidemic from every point of view. The facts and statistics given are very valuable and instructive for various reasons. They relate to an epidemic of fairly large proportions, and are therefore of considerable weight. The epidemic occurred in a population of great uniformity, and accordingly we are not confused by considerations arising from complex social conditions. The conclusions arrived at are thus more to be relied on than they otherwise might be.

For these reasons it is desirable to have the information given in the Report to the Royal Commission published in a short succinct form, easily accessible. This I have endeavoured to do, showing the causes of the spread of the epidemic and the measures which were successfully taken to bring about its decline.

STONEHAVEN, N.B.

June, 1902.

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HOW IT IS SPREAD AND HOW IT MAY BE PREVENTED.

CHAPTER I.

In the year 1773, Warrington was visited by a terrible scourge of small-pox. As we shall have occasion in the course of our enquiry to refer to this epidemic and to compare some of its features with those of the epidemic of 1892-93, it is desirable to give a short account of it. The information we have is derived from Essays by Dr. PERCIVAL of Manchester, published in 1788 by Dr. AIKIN in the "Transactions of the Royal Society," and from other sources. At that time the population of Warrington was about 8,000, and the conditions of life compare very favourably in most respects with those in 1892, so that we are able to compare with fairness the relations of small-pox with the community at the two periods. In 1773, vaccination had not yet been discovered. Inoculation, however, was practised, and possibly some ten or twelve persons had had the operation performed. This small number, however, is of no importance in considering the incidence of small-pox in the community. In 1892, on the other hand, we find that the vast majority of the inhabitants had been vaccinated once. This is the main difference between the two communities.

From accounts of the causes of death at the end of the eighteenth century and the general death-rate, we find that the health of the people was not very different from that of 1892. With the exception of deaths from small-pox, we have reason to believe that the people of Warrington in 1773 were as robust and strong as in 1892. The general environment in 1773 would certainly be better than in 1892. In 1892, we find that the town had grown largely; that it is a busy, manufacturing place, where the atmosphere is close and unhealthy. Dr. SAVILL found that the general appearance of the people was like their surroundings. They were dull and careworn, and they very generally suffered from anæmia. In 1773, on the other hand, there were few manufactures, and these were of a healthy nature. The chief was sailmaking. As regards general cleanliness, there can be no doubt that the people of 1773 were in no way behind their descendants of 1892. On the whole, we may be tolerably certain that the people of 1773 were not in themselves more prone to disease, nor worse subjects when attacked by disease than the people of 1892.

On the whole, then, the comparison between the two communities as regards small-pox is one between an unvaccinated and a fairly well vaccinated community. In other respects the conditions are not unequal.

The statistics of the two epidemics also are fairly to be compared, as the figures in both cases are reliable. It is unlikely that there would be any greater error in the total number of cases in the one epidemic than in the other, for, in regard to the diagnosis of small-pox, there would be little difference in medical skill. At the end of the eighteenth century, small-pox was a familiar disease, and there is no reason to suppose that there was any confusion between small-pox and other diseases further than there might be in 1892. Nor need we suppose that any difference in the death rate from small-pox in the two periods was due to any great improvement in the treatment of the disease, for there has been no great advance in this direction. The disease is not yet very amenable to treatment. In unvaccinated persons, and especially unvaccinated children, it is still a very fatal disease, and in 1773 the incidence of small-pox was mainly among young people.

In considering the relations of vaccination and small-pox, the chief points to be considered and compared are: the attack rates, the mortality rates, the ages at death of fatal cases, the age incidence of the disease, and the case severity in the two epidemics and in various classes of persons.

Meanwhile it is of interest to look at some of the chief features of the 1773 epidemic. These are :—

(1) The death rate was very heavy—211 out of a population of 8,000—being as many deaths from small-pox alone as from all other diseases together.

(2) The remarkable fact is shown that all these deaths were of children under nine years of age. In contrast to this we find that, in the epidemic of 1892-93, the deaths among vaccinated persons only began at this age. This points to the undoubted fact that vaccination in 1892-93 afforded protection for at least nine years, while in 1773 there is the practical certainty that persons over nine years, for the most part, had already had small-pox and were so far protected. We know from other sources that, at that time, nearly everybody had small-pox at one time or another.

The disease is one of the most contagious. It is stated that, during the eighteenth century, half-a-million of people died from it in Europe. In some years, it caused half the deaths of children under ten years of age. It is known to spread with extreme rapidity among any people, when it is first introduced. It spares neither high nor low, rich nor poor, young nor old, and we may be sure that in 1773, the great majority of adults had already had the disease.

(3) In Table XX of the Report, we find that the average age at death in this 1773 epidemic was 2½ years, as compared with 33 years among the vaccinated in 1893, and 14 years among the unvaccinated. The difference from 2½ to 14 among unvaccinated persons, simply means that, in 1892-93, there were more persons of all ages susceptible to small-pox than in 1773, when nearly all adults had already had a previous attack.

We may compare some points in the two epidemics at this stage.

The attack rate, *i.e.* **the number of persons attacked out of 1,000 living.**—In 1773 the attack rate may be deduced from a statement drawn up at that time by Mr. Aikin, who says that 12 in every 29 attacked, died. As there were 211 deaths, this means that about 510 persons were attacked. The population was about 8,000, and this, then, gives us an attack rate of 63.7 per 1,000. This compares with an attack rate in 1892-93 of 11 per 1,000.

The mortality rate, *i.e.* **the proportion of deaths to each 1,000 persons living.**—In 1773, this was 26.4 per 1,000, as compared with .6 per 1,000 in the vaccinated population of 1892-93.

The case mortality, *i.e.* **the proportion of deaths to the total number of cases.**—This can be calculated from the figures given by Mr. AIKIN, who gives us the statement that 12 out of 29 attacked, died. This means about 40 per cent. as compared with 35 per cent. among unvaccinated persons in our time—no very great difference.

The age incidence we have already referred to. In 1773 there were no deaths over 9 years of age. The average age of death was 2½ years, against 33 years among the vaccinated in 1892-93, or taking all cases, 26 years.

Dr. SAVILL says :—" If we take the small-pox deaths in decades of ages, as in Table XXI, it would seem that vaccination shifts the age-period in which the maximum number of deaths occurred onwards from the first decade to the fourth decade of life.

"This important causal connection receives confirmation from the fact that the first decade is the one chiefly affected among the unvaccinated in 1892-3. And this latter comparison deals with persons living side by side under precisely the same conditions, excepting as regards their having been unvaccinated or vaccinated respectively."

Among the vaccinated in 1892-3, there were no deaths below nine years.

During the years 1774-1790, small-pox was not absent from Warrington. The records are missing, but from "Observations" appended to Bills of Mortality, drawn up by Dr. DANIEL MOSS for the Corporation, for 1791-92, we learn something. The following is an extract from his "Observations":—

"The circumstance that hath occurred to raise the list of deaths of the present bill so much higher than that of the preceding, must be solely ascribed to the natural small-pox, as the mortality from other causes is diminished. This epidemic (the scourge of the human race) prevailed for the most part during the year 1792, though not to the extent or with the malignity we have before experienced. As it made a complete progress through the town in 1790, there were comparatively few subjects capable of receiving the infection. From this, as well as the facts in our former bills, it appears that the spread of small-pox at a place depends solely upon the number of people liable to take it, and not upon any peculiar state of the air."

By a study of the condition of Warrington at the end of the eighteenth century, we get a very clear picture of the natural history of small-pox as it flourished before any measures preventive in the individual or among the community at large were taken. We are generally too apt to overlook this part of the subject, and many people altogether ignore the real state of affairs. We are too ready to think of small-pox with levity, as it has been robbed of its terrors. Since the introduction of vaccination, the disease has been an infrequent visitor and usually does not spread to any great extent. Most of the cases, too, are mild. The examination of this epidemic of 1773 shows us, however, what a formidable disease it is amongst an unprotected community. A mortality of 12 out of 29 cases is sufficiently appalling. That this mortality was not unusual is confirmed by the statistics of small-pox amongst the unvaccinated in 1892-93, a nearly similar proportion of whom succumbed to the disease.

CHAPTER II.

A CONSIDERATION of the small-pox epidemic of 1773, gives us a pretty fair idea of what we may call the natural history of small-pox uninfluenced by vaccination or other sanitary measures. By following the course of the epidemic of 1892-93, we can see how the disease spreads in a community of the present time—fairly well vaccinated.

The first question one asks is: Why, if the population was vaccinated, and sanitary measures carried out properly, there should be any spread? We might naturally expect that in such a community, with early recognition of cases, prompt and sufficient isolation, and quarantine, infection would not spread.

The answer we find very clearly set forth in the Report to the Commission. It amounts to this: that those measures were not carried out to their full extent, and that it was by a failure of sanitary measures in the first instance that the epidemic did spread, among a population well vaccinated, indeed, but not re-vaccinated; and, finally, that it was by a more rigorous application of sanitary measures and by wholesale re-vaccination that the course of the epidemic was stayed.

In April, 1892, a farm-worker at Clifton near Brighouse, Yorkshire, was laid up for a few days with what his doctor called measles, and getting up, soon afterwards went about as usual. This case, as shown by its effects, was really small-pox. Shortly after this patient got about, the farmer and his family removed to Latchford, near Warrington, and a day or two after arrival he, his daughter, and son developed small-pox. After five days' delay, the whole family was removed to the Warrington Borough Fever Hospital and the house and contents disinfected. From this, one other case developed—one of the two men employed in disinfection. No other case occurred for nearly two months. The reason why the disease did not spread further was that the house where the outbreak occurred was an isolated one surrounded by fields, and the people had no friends in or around Warrington. In this way there was little or no intercourse with other people, and consequently there were no opportunities for infection.

After an interval of nearly two months, a navvy residing at a common lodging-house in the centre of the town was taken ill and kept to his bed. He developed the rash of small-pox on 26th July,

1892. Two days later, the owner of the lodging-house walked with the man through some of the principal streets to a doctor and thence to the Borough Fever Hospital. He died on August 5th. He had never been vaccinated.

The lodging-house was disinfected, and so far as is known only one person developed the disease among its inmates ; these were seventy in number.

In other directions, however, the case was different, and from this man the epidemic took origin. The source whence he himself was infected is obscure, but the manner in which the disease spread from him is remarkably clear, and illustrates well the points where sanitary and hospital measures are apt to be at fault.

The case was a severe confluent one ; and in his delirium the patient escaped from the hospital between one and two o'clock in the morning of Saturday, July 30th. He was at large for six or seven hours. He escaped by the main gate of the hospital, which he left open, and visited the market, which is very busy on a Saturday morning. He was apprehended by a constable in Winwick Street, two-thirds of a mile away, and conducted by him back to the hospital on foot, about 8 a.m., through some of the busiest thoroughfares, where he probably came in contact with many foot passengers.

This weak spot in administration was the first determining cause of the epidemic. Had this man not been allowed to get away, there is every probability that the disease could have been kept within bounds, even although, as we shall see, the sanitary administration was weak in other respects.

The next important factor in the spread of the epidemic was the non-recognition of certain of the cases arising from Case 1. They were four in number; all seen by a doctor's assistant, said to be unqualified, acting in the absence of his principal. These four cases were called German measles, and were treated at home; while the friends went to work or play freely without let or hindrance. These cases may be quoted to show the manner in which they acted as disease centres.

CASE 13.

Elizabeth S., æt. 36, a vaccinated but not revaccinated person, the mother in a household of ten, after ailing a few days, developed the rash of discrete small-pox on August 16th. Next day she sent for her doctor. Unfortunately the doctor was away for a holiday, but the assistant left in charge, who was alleged to be unqualified, called, and pronouncing the case to be "German measles," (although the spots are reported to have had white heads to them), treated the case at home as such for ten days. On August 25th, the Medical Officer of Health, hearing rumours of the case, visited her, and she was removed next day (August 26th) to the hospital. But during those ten days the visits of friends and neighbours were unrestricted ; her husband and son went to work, and her seven other children were playing daily (for it was fine weather), with others in the open spaces, back and front, of the houses in that row. Three of her own well vaccinated children (aged 14, 12 and 9), subsequently contracted the disease ; and altogether twenty-three cases developed the eruption between August 30th and September 12th in the houses around the open spaces in front and rear of this house and that of Case 10.

CASE 10.

Henry B., æt. 10, living in the same street as the foregoing, was taken ill on the 14th, and developed the characteristic rash on Aug. 17th. The same "doctor's assistant" as in the preceding case was at once sent for and saw the boy. This time also the case was designated "German measles." The child was unvaccinated, and the case a severe confluent one, but it was not until the 23rd (on the seventh day of the rash) that it was recognised and removed to hospital, where the little boy died three days later. Meanwhile friends and neighbours visited the house freely, and the father worked all the time at the Dallam and Bewsey Forge, which takes so prominent a position in the future history of the epidemic. The father himself developed the rash fourteen days after his son (although he was reported to have had small-pox thirty-three years before); and the barber whom the "doctor" ordered to cut the hair, also took the disease. Three brothers and sisters, and the child's mother, all well vaccinated, escaped. Twenty-three cases resulted, as just mentioned, in the immediate neighbourhood of these two cases, and altogether thirty out of the fifty cases forming the next batch arose in this (the Whitecross) ward. There were other two cases seen by the same doctor's assistant and not recognised.

Besides these, there were other cases not recognised early—some mild, but none of them were followed by the same spread of the disease as the two quoted.

The cases arising in consequence of infection from Case 1 were fifteen in number, and constitute the second group of cases. These occurred in the week August 16—23, two being in the Borough Fever Hospital. Of the others, only two were promptly recognised and removed, and of the remaining eleven—

1 remained at home 10 days.
1 " " 7 "
1 " " 6 "
3 " " 4 "
1 " " 3 "

all with the rash out.

4 cases were never removed at all.

This brings us to a second point: The want of hospital accommodation.

At the time the disease was spreading, there was a concurrent epidemic of scarlatina, with many cases in hospital. The consequence was that only thirteen cases of small-pox could be accommodated in the Fever Hospital. This necessitated the leaving at home of the four cases mentioned.

The results arising from having patients left at home, without isolation in this way, were what might be expected—a very decided increase in the number of cases.

It is instructive to notice *the causes of delay.* They were :—

(1) *Non-recognition of the disease.*
(2) *Delay in seeking medical aid.*
(3) *Want of room in the hospital.*

In four cases the patient, or his friends, did not consult a doctor immediately, and one of them was never seen or notified at all. Three of them were very mild cases, and infections from them were not, comparatively speaking, very numerous. Four cases were seen and not recognised by the doctor's assistant, acting in the absence of his principal, and one of these was never notified. Two other cases were not recognised by the doctor.

In all the cases, removal was very prompt after notification until the time when the hospital was full.

From a consideration of the above facts, we find that, in the face of an epidemic, there are some points which are beyond the control of any sanitary authority. There is no way of ensuring that cases will be recognised early, or that mild cases will be seen by a doctor. In this way it is plain that, in a susceptible community, small-pox if introduced is very likely not to be controlled, or at all events checked, by any merely sanitary measures. What is wanted to complete the defensive armour of the community, is to render the individual members of it immune to small-pox, or as nearly so as is possible. We find that vaccination and re-vaccination do this better even than a previous attack of small-pox, and there is nothing else that can afford a similar immunity.

It is made clear by the investigations into these fifteen cases that the source of infection was undoubtedly the first case, the man who escaped from hospital. He was for a while the only known case in the town. All the cases in this group developed the disease within a few days of each other. The group was preceded and followed by quiet intervals without cases, and this of itself points to a common origin.

The cause of the spread of small-pox within the hospital was, certainly, insufficient isolation of this first case, and of all the other cases as they arose. The task of isolation was rendered extremely difficult by reason of the insufficient accommodation provided by the sanitary authorities. The hospital accommodation was reported by the Medical Officer of Health as insufficient, some considerble time before the outbreak of small-pox. Even after the epidemic began, there was great delay in remedying this, and it was only when the matter was urgent, and could no longer be put off, that the authorities gave full power to the Medical Officer, and finally provided the requisite accommodation.

Owing, then, to this lack of proper isolation, the disease spread in the hospital. The manner in which this occurred is worthy of note.

"The first person to contract the disease was the kitchen-maid, who daily fetched and cleaned the plates used in the Doëcker tent in which the first case was isolated. On the same day, a little scarlet-fever patient, who had been up and about, developed the disease. She was moved, soon after the appearance of the rash, to the nurses' 'duty-room,' in the centre of the convalescent scarlet-fever pavilion, in which all the cases of small-pox, but two, subsequently arose." Those cases show that the administration of the hospital was lax, and that the importance of their actions was not understood or appreciated by the staff.

The disease at this time also invaded the Workhouse, and spread there. The Workhouse is situated near the Borough Hospital, being separated from it by a high wall. The source of infection could not easily be traced, but probably came from outside. The cause of the spread of the disease, apart from the question of vaccination and re-vaccination, was, again, deficient isolation. "In all cases," says the Report, "direct contagion could easily be traced"; and the remarkable absence of unexplained infections is commented on.

Beyond the spread of the disease within the Fever Hospital and within the Workhouse, the infection spread in other directions.

The son of Case 13, Mrs. S., remained all the time (10 days) that the case was unrecognised and unisolated, working at the Dallam and Bewsey Forge. Here, too, the father of Case 10, also previously mentioned, remained for seven days, during which time his son remained at home, unisolated, with the rash out. There were altogether at this time five different sources of infection to the operatives in this forge.

If all these fifteen cases forming Group II. had been recognised early, removed promptly, and properly isolated, the epidemic at this stage would likely have been kept within small bounds. However, as things were, as the result of non-recognition, non-removal, and want of room for all the cases in the the hospital, there developed a number of fresh infections producing altogether a group of no fewer than fifty cases.

Beyond all doubt, the largest number of these fresh infections resulted from the cases seen by the doctor's assistant.

We thus see the far-reaching effects of non-recognition of early cases, and the corresponding benefit to be derived from early recognition followed by notification and isolation.

During this stage of the epidemic, the want of hospital accommodation was very pressing, and was a factor of the utmost importance in the spread of the epidemic. Only thirteen cases could be received into the Fever Hospital at one time. Between Aug. 30 and September 13, there were fifty fresh cases, for which, together with previous cases, only those thirteen beds were available.

As beds became vacant, four of the fifty patients were taken into the hospital. Twenty-six were left at home for periods varying from three to twenty-six days, with the eruption out. Fourteen others were never removed to hospital at all. Thus there were no fewer than forty cases at one time left in their own homes, unisolated, each acting as a fresh focus for the spread of infection.

On September 19, a temporary new hospital was opened for the reception of cases. About this time there was a lull in the epidemic, but during the week ending Sept. 24, twenty-seven persons developed the rash. During the week ending October 1, thirty-five persons, and finally during the week ending Nov. 12, eighty-eight persons.

"We find," says the Report, "on Sept. 19, that there were no fewer than forty-six cases of small-pox which had remained in their own homes after the appearance of the rash for periods varying from seven to twenty-one days, surrounded by ignorance, dirt, and in many cases destitution, for as we shall see, all the infected houses in the Warrington Epidemic, with few exceptions, belonged to the labouring and lower classes."

After November 12th, we have a continuance and then the decline of the epidemic, but at this point it had reached its climax.

The further spread from this stage we need not consider here. The causes were undoubtedly, in the main, the considerable number of cases left at home without sufficient isolation. Other factors contributed, but these were the chief sources of infection.

We must next consider what were the causes which operated to produce a decline in the epidemic. We have seen that there were no factors operating to cause a diffusion of infection, beyond the ordinary one of allowing the epidemic to run its natural course. We shall now find that as the various channels of infection were closed, and particularly as the inhabitants were rendered immune by re-vaccination, the epidemic passed away.

On November 16th, the Guardians afforded increased facilities for re-vaccination: (1) by opening the public vaccination stations on an additional afternoon and on an evening each week; (2) by appointing two assistants to the vaccination officer for house-to-house visitation.

The Town Council empowered the Medical Officer of Health to establish five stations for gratuitous vaccination in the borough, and to secure the services of five medical practitioners to perform vaccination.

Placards, urging the inhabitants to be re-vaccinated, were posted over the town.

During the latter part of November and the early part of December, large numbers of people flocked to the vaccination stations, now seven in number, to be re-vaccinated.

It was estimated by the Medical Officer of Health, that over one-third of the population had been re-vaccinated by the middle of December.

"Throughout the epidemic the daily and weekly number of cases preserved the usual wave-like character. Finally, the numbers became less and less, gradually, but irregularly, like the waves of a receding tide."

In conclusion. From a consideration of the circumstances of the spread of the epidemic, we find the following to be the main features:—

(1) The preliminary outbreak in May, 1892, was effectually dealt with by isolation, disinfection, and quarantine.

(2) The main outbreak arose by the spread of

infection from a navvy of the wandering class, in consequence of his insufficient isolation.

(3) Thereafter the epidemic spread in successive waves, one group of cases giving rise to another group in consequence of various causes, the chief being: delay in seeking medical advice, non-recognition of cases, want of hospital accommodation, absence of re-vaccination.

(4) The disease gradually declined as re-vaccination became more general and as the means of coping with the epidemic became more perfect.

CHAPTER III.

UNDOUBTEDLY the chief factor in determining the rise and spread of the epidemic, and afterwards the fall in the number of cases of small-pox, was the condition of the population as regards vaccination and re-vaccination.

As the benefits derived from vaccination are so much disputed by some, and the question is so important from every point of view, I shall quote freely from the facts given by Dr. SAVILL in his Report to the Royal Commission. We have in the Report very full and accurate statistics, so complete in every way, that there can hardly be any question raised without finding an answer in the figures given.

As regards vaccination, then, it is claimed that it has the following two separate powers in relation to small-pox:—

(1) *Power to protect from small-pox.*
(2) *Power to modify small-pox.*

It will be admitted that these effects are temporary and not permanent; and, again, the power to protect from small-pox may last a longer or a shorter time than the power to modify small-pox.

These separate points are made absolutely clear in the statistics given in the Report. The figures are large enough to render the conclusions drawn from them reliable.

We have to consider first the question :—

Has Primary Vaccination any power to protect from small-pox ?

The question may be approached from various points of view.

(1) We may take two classes of houses: infected and uninfected, and compare the proportions of unvaccinated persons in them. We find the proportions to be :—

In the infected houses 4.2 *per cent. were unvaccinated.*

In the uninfected houses 0.74 *per cent. were unvaccinated.*

Instead of taking the uninfected houses by themselves, we may take a typical district of the town, comprising all the houses in it, whether infected or non-infected. We find that the proportion in that case is as follows :—

In a typical part of the town, 0.8 *were unvaccinated.*

The exact figures are sufficiently large:—

Number of infected houses, 437.
Persons living in them, 2535.
Persons unvaccinated, 107, or 4.2 per cent.

Number of houses in typical district, 663.
Persons living in them, 3394.
Persons unvaccinated, 29, or 0.8 per cent.

From this we see that in the infected houses by themselves, there were five times as many unvaccinated persons living as in an ordinary typical district of the town. It would appear as if the disease had selected in a great measure those houses where the largest proportion of unvaccinated persons lived.

(2) Again, taking the two classes of houses—infected and uninfected,—we may compare the persons who had been vaccinated so as to ascertain their relative vaccinated condition. We find that in the uninfected houses there is a larger proportion of well-vaccinated persons than in the infected houses.

(3) We may consider the relative proportions of persons attacked by small-pox, among several groups of vaccinated persons, in the infected houses. These groups are based upon the different degree

of success in each as regards vaccination. They are :—

Well vaccinated.
Indifferently vaccinated.
Doubtfully vaccinated.
Unvaccinated.
Re-vaccinated.
Those who had had small-pox previously.

For all these different groups, we may take it that in the infected houses the exposure to infection was equal.

Taking first the comparison between the vaccinated and unvaccinated persons, we find that in 437 infected houses there lived 2,387 persons who had been vaccinated, and 107 persons who had never been vaccinated.

Out of 2,387 *vaccinated*, 553 took small-pox, being 23 *per cent.*

Out of 107 *unvaccinated*, 60 took small-pox, being 56 *per cent.*

Beyond this difference as regards vaccination, there was no other between the two sets of people. "They lived in the same houses, ate the same food, often did the same work, and were exposed to the same hereditary and external influences."

Taking the different classes of vaccinated people in the infected houses, we find that the following percentages were attacked :—

Among the well-vaccinated	21.6	per cent.
„ „ indifferently vaccinated	27.4	„
„ „ doubtfully vaccinated	25	„
„ „ unvaccinated	56.1	„
„ „ re-vaccinated	11.1	„
„ those who had had small-pox previously	12.2	„

“From this comparison, we find that—

“(*a*) The proportion of those attacked is greater among the indifferently and doubtfully vaccinated than among the well-vaccinated.

“(*b*) The proportion among the unvaccinated is more than twice as high as among the doubtfully vaccinated.

“(*c*) The proportion attacked amongst those who had small-pox previously is larger than amongst the re-vaccinated, the proportions being 12.2 and 11.1 respectively.”

(4) We may next contrast the figures in the epidemic of 1773 with those for the epidemic of 1892-3. From this we find that—

The actual attack rates were, in 1773, (amongst the unvaccinated), 64 per 1,000; and in 1892-3, (amongst the fairly well vaccinated), 12 per 1,000.

Further, we find that whereas the disease was endemic in the unvaccinated community, it is only epidemic in the almost entirely vaccinated community.

Also, we find that the average number of deaths from small-pox in Warrington from 1773 to 1842 was 35 per annum, the population being small and unvaccinated. On the other hand, from 1843 to 1891, in a population much larger, but well vaccinated, the average number of deaths from small-pox was only 5·6 per annum.

All these undoubted facts go to prove, conclusively as it appears to me, that vaccination has power to protect from small-pox, and that in a high degree.

Having shown that a large measure of protection from small-pox is afforded by primary vaccination, there remain cases where small-pox develops although vaccination had been performed. This may be owing to various causes, such as lapse of time, degree of success of vaccination, etc. The question then arises:—

Does Primary Vaccination possess any power to modify small-pox?

This may be ascertained by examining into—

The severity of the disease, and
The fatality of the disease.

As regards severity, the attack is classified as mild, discrete—*i.e.* the pustules or pocks are separated by intervals of healthy skin, or confluent—*i.e.* the pustules or pocks are run together over large areas of skin. We judge of the power of vaccination to modify the disease according as we find that the attack is more or less severe in unvaccinated than in vaccinated persons. We find that the following are the facts :—

(*a*) Comparing 586 vaccinated cases with 68 unvaccinated cases, there were, relatively, nearly 16 times as many mild cases among the vaccinated persons as among the unvaccinated, and less than a third as many of confluent cases, as the following table shows :—

	Vaccinated.	Unvaccinated.
Mild . . .	56 per cent.	4.4 per cent.
Discrete . .	23 " "	25 " "
Confluent .	22 " "	70 " "

Taking the same cases, we find that the percentage of fatal cases is nearly six times as great amongst the unvaccinated as amongst the vaccinated.

The figures are :—

Vaccinated . . .	6.5 per cent.
Unvaccinated . .	35.0 ,, ,,

(*b*) There are also to be considered the type of case and fatality amongst the different classes of vaccinated people.

The Tables in the Report show clearly that the proportion of severe cases was greater according as the vaccinated condition was less perfect. The mild, discrete, and confluent cases in the various classes were :—

	Well Vaccinated, **350.**	Indifferently Vaccinated, **208.**	Doubtfully Vaccinated, **28.**
Mild . .	60 per cent.	56 per cent.	43 per cent.
Discrete .	23 ,, ,,	22 ,, ,,	14 ,, ,,
Confluent .	17 ,, ,,	22 ,, ,,	43 ,, ,,

Among the same cases the fatality in the various classes was 2.9 per cent., 8.2 per cent., and 39.3 per cent. respectively. In unvaccinated cases, 35.3 per cent.

(*c*) A consideration of the ages at death of the fatal cases gives us valuable information, and shows that the effect of vaccination was to increase the average age at death from small-pox by nearly twenty years.

The average age at death amongst the unvaccinated fatal cases was 14.8 years.

The average age at death amongst vaccinated fatal cases was 33.3 years.

The same conclusion is arrived at by considering the age at death in the epidemic of 1773. In that epidemic the average age at death was 2½ years. All the deaths were of persons under 9 years of age, the very age at which deaths of vaccinated persons commenced in the epidemic of 1892-93.

From a consideration of these various points we are bound to conclude again in favour of vaccination. Besides having a power to protect from small-pox, it also has shown itself able to modify that disease. In cases where small-pox has attacked vaccinated persons, the disease has proved to be less severe and less frequently fatal. Beyond this it is abundantly clear from a consideration of the facts stated, that the less perfect the vaccinated condition, the more severe is the attack of small-pox and *vice versâ*; and, further, the longer the time that has elapsed between the performance of vaccination and the attack of small-pox, the more severe is the attack.

In one word, vaccination possesses the power to modify small-pox in the person vaccinated.

The duration of protection from Small-pox afforded by Primary Vaccination.

As we might suppose from other considerations, the immunity procured by vaccination wears away as life advances. The duration of protection is shown by examining the attack rates at different age-periods among the vaccinated, and comparing them with the attack rates at the corresponding age-periods among the unvaccinated.

The heaviest attack-rate amongst the vaccinated cases occurs in the third decade of life—47 per cent. This is more than twice that of the decade below. In the first decade it is only 4.4 per cent. This shows that the comparative immunity in the first decade is due to vaccination, and that after the age of twenty the immunity wears off.

In the fourth, fifth, and sixth decades, the attack-rate again decreases, due to the fact that advancing years confer a partial immunity to most infectious diseases.

The duration of the power to modify Small-pox which Primary Vaccination possesses is shown by a study of severity and case-mortality at the different age-periods of life.

The case-mortality among the vaccinated cases is 6.5 per cent., that among the unvaccinated being 35·3 per cent. The case-mortality amongst vaccinated persons increases relatively to that amongst unvaccinated persons up to the fourth decade, when it is highest. This means that a modifying power exists, which is greatest in the early years immediately following the time of vaccination, but continuously diminishes up to the age of 40. We find also that the severity of the disease increases in the vaccinated cases up to the decade 40 to 50, and then diminishes. This is shown by the proportion of confluent cases, which is greatest in that decade. It thus appears that the power of vaccination to modify small-pox lasts longer by some twenty years than its power to protect from infection, for the power to modify is least in the fifth decade, and the power to protect is least in the third decade.

From these facts we may conclude that the best time for re-vaccination to be performed is during the second decade.

Small-pox in persons under 10 years of age.

Of these cases we have Tables in the Report, giving particulars. There were altogether sixty-five cases, or 10 per cent. of all cases.

33 cases were vaccinated, and
32 „ „ unvaccinated.

The figures given are very instructive, and show, as between the two sets of cases, that, among those exposed in the infected houses, the attack-rate of the unvaccinated cases was ten times as high as for the vaccinated cases, and that there were eleven times as many confluent cases, and six times as many deaths.

This is shown in the Table given on p. 36.

The proportion of unvaccinated children who died, of those attacked, is remarkably near the proportion given in the estimate for the epidemic of 1773. In that epidemic all the deaths were of children under 10, and in the proportion of 12 out of 29. Now, in 1892-93, the ratio was 12 to 32. This similarity is sufficiently striking and brings into greater prominence the state of affairs among the vaccinated children in the infected houses. In those houses there were 272 children under 4 years and vaccinated. Not one of them contracted the disease, a thing we can hardly conceive would be possible had they been unvaccinated.

	ATTACK RATE.	CASE SEVERITY.				
Children under 10 years.	Percentage of persons attacked amongst those exposed in the infected houses at that age.	Mild.	Discrete.	Confluent Hæmorrhagic Malignant.	Deaths.	Percentage Fatality.
Vaccinated, 33 cases	5.1	24	7	2	2	6.0
Unvaccinated, 32 cases	56.1	2	7	23	12	37·5

CHAPTER IV.

THE effects upon small-pox of re-vaccination ; concurrent vaccination ; a previous attack of small-pox ; the supposed ill-effects of small-pox, and the character of vaccination scars, fall to be considered next.

The influence of Re-vaccination upon Small-pox.

In houses invaded by small-pox, there lived sixty-three persons who had been re-vaccinated. Of these (excluding one who had previously had small-pox), seven were attacked. This is a percentage of 11.1. As compared with this, we find that of those who had small-pox previously the percentage attacked was 12.2. This brings out the very remarkable fact that *re-vaccination affords more protection against small-pox than a previous attack of the disease does.*

In the seven cases, the several intervals between re-vaccination and the attack of small-pox were: seven years, eight years, fifteen years, twenty years, twenty-two years, twenty-five years, and twenty-seven years. The shortest interval is seen to be seven years.

An interesting case is one where the patient, Mary M., aged 30, who had been re-vaccinated, and had an attack of small-pox, in spite of all developed the disease again. She was vaccinated in infancy in 1863; was re-vaccinated in 1873; had small-pox in 1873; and had small-pox again in 1893.

As showing the power of re-vaccination to protect from small-pox, Dr. SAVILL gives some instructive points in the Report. They are:—

(1) The attack-rate, in the infected houses, amongst re-vaccinated persons was less than that amongst those who in the same houses had had small-pox previously, the figures (already given) being 11.1 and 12.2. These are based on small numbers, but the similarity of percentages is worthy of note.

(2) Not one of all the 667 cases of small-pox had been successfully re-vaccinated less than seven years prior to the epidemic.

(3) The only two members of the Aikin Street Hospital staff who had not been re-vaccinated at the commencement of the outbreak, were the only members of the staff who contracted small-pox.

(4) There were instances where prompt re-vaccination seemed to prevent the spread of the disease in an infected household.

(*a*) Case 589, aged 18, the only one of a family of eight who refused re-vaccination, developed the disease.

(*b*) Case 624, aged 23, refused vaccination. Six others of the family, all over 11 years of age, were re-vaccinated then and escaped, although two of them slept with the patient after the eruption came out.

(*c*) Case 377 (one of a household of 16) was at home three days with the eruption out. All the others in the house over 11 years were re-vaccinated on the day the patient was removed, and not one of them was subsequently attacked.

(5) Re-vaccination was performed extensively in the principal "Works" in the town, and in many the disease diminished, or ceased to occur, the diminution beginning chiefly fourteen days after a large number of re-vaccinations had taken place.

(6) There was only one case of small-pox in the Barracks among about 800 persons altogether. Of these, the recruits to the Regular forces are re-vaccinated on joining. The recruits to the Militia are not re-vaccinated unless their marks are imperfect. At the time of the epidemic an inspection was made and re-vaccination performed wherever the original marks were reported not to be good.

Some cases occurred in which re-vaccination was unsuccessful, but yet an attack of small-pox was contracted. Such cases show that it is wise to perform the operation another time where the vaccination has not been successful. The want of success may be due to some other cause than immunity.

The effects upon one another of Concurrent Vaccination and Small-pox.

From a Table of Cases where persons who had been re-vaccinated took small-pox, we find that in all cases the rash developed within twelve days after vaccination or re-vaccination (there is one doubtful case of an infant who had some "pimples" after twelve days). The inference is that if a person has been exposed to the infection of small-pox, the protection afforded by vaccination can only be procured if vaccination be performed at least twelve days before the rash may be expected. As the rash of small-pox usually appears fourteen days after infection, this allows of two days only after exposure to infection during which we may hope that small-pox may be averted by vaccination.

If, in the event of exposure to small-pox, vaccination is performed later than two days afterwards, then small-pox may supervene. In that case, the disease and the vaccination will run concurrently. It might be supposed that there would then be some modification of either or both. Such does not seem to be the case. There is no evidence to show either that the vaccination is in any way different from that in an ordinary case, or that the small-pox following is at all affected by the vaccination.

The effect of Vaccination on Children born of mothers who had suffered from Small-pox during gestation.

There is nothing to indicate that small-pox is an intra-uterine disease. No child has ever been born pitted. Still we may consider it probable that the immunity procured by the mother during her attack of small-pox would be extended to the fœtus by means of the placental circulation. This would be analogous to what occurs in some other diseases, and seems to be really the case.

The number of illustrative cases is small in the epidemic of 1892-93, but they tend to show that such children after birth are unsusceptible to vaccination. In none of the cases observed did the child develop small-pox after birth.

The influence of Small-pox on Small-pox.

As in most infectious fevers, one attack protects the individual from a second; but as in other fevers, so in small-pox, protection cannot be relied on after a lapse of time.

In the Warrington Epidemic, out of 667 cases of small-pox, there were five in which there was satisfactory evidence that they had previously suffered from an attack of small-pox. None of these had been re-vaccinated in the period just before their attack, as naturally they would consider themselves pretty safe. The shortest interval in these cases between the two attacks of small-pox was nineteen years.

On the character of Vaccination scars.

We have already seen that in the uninfected houses there was a higher ratio of "well-vaccinated" persons than in the infected houses. Also in the infected houses a larger proportion of the "indifferently vaccinated" (27 per cent.), were attacked than of the "well vaccinated" (21 per cent.). It is also shown in the Report that the case mortality amongst the "doubtfully vaccinated" (40 per cent.) was considerably higher than amongst the "indifferently vaccinated" (9 per cent.); and this again was higher than amongst the "well vaccinated" (3 per cent.).

The different classes of vaccinations are based upon the appearance of the scars. A larger proportion of the indifferently vaccinated persons is found in the later decades of life, when the power of protection from small-pox possessed by vaccination is passing or has passed away, and the power of modifying small-pox is diminishing. We thus find that the appearance of the scars is to a certain extent a guide to the amount of immunity possessed by the individual. It is not to be supposed that the rate at which scars subside or become obliterated corresponds exactly to the rate at which the loss of power to protect from or modify small-pox is lost. In fact, the rate of obliteration of scars is very variable, and nothing certain can be said about it. It is also quite impossible to tell from the depth of a scar what degree of success there has been in the vaccination. The important thing in respect to a scar is its superficial area. From the facts of the epidemic of 1892-93, it would appear that the size of the cicatrix is an index of the amount of protection afforded by vaccination, half a square inch of surface being a fair size.

Besides the size of the scar, there is little else of importance. Where the cicatrices are of sufficiently large area, they are usually foveate or pitted.

As regards re-vaccination scars, they are little different from primary scars, but they are usually smaller and disappear in a shorter time than the primary ones. They are only occasionally foveate, and they tend to become less so. They also tend to become smaller after repeated re-vaccinations.

On the evils alleged to arise from Vaccination.

This is the point to which anti-vaccinators and conscientious objectors attach importance. There is, in fact, no other point of view from which to object to vaccination ; and, naturally, this is made the most of. It is beyond the scope of this work to inquire into the methods of procuring lymph. It is well known that every precaution is taken to ensure that there are no organisms of a pathogenic nature present. Any evils alleged to arise from vaccination, must, to be of any force as argument against its use, arise, not from extraneous sources, but from the very *materies* of the lymph. Evils from any outside source, if present, may be eliminated, but not so if arising from the very essence of the lymph. Hence the importance of showing any evils arising from vaccination *per se.* Such evils are conspicuous by their absence. In the epidemic of 1892-93, 5,778 cases were enquired into. In only three cases were any specific allegations made. In none of the three cases had vaccination anything to do with the evils alleged against it. It still remains to be shown that vaccination of itself has any ill-effect. In vaccination, as in any abrasion of the skin, there may be an entry of pathogenic organisms from other sources, but any evils resulting from this are not to be laid against the operation of vaccination. Cases of rashes appearing after vaccination arise usually from this source. Some of these rashes may be compared to the preliminary rashes which occur in small-pox. We find others of the same nature as the so-called inoculation rashes occurring after injection of serum and animal extracts. Sometimes eczema follows these rashes by a mixed infection taking place. These evils are, however, not very frequent, and most people will think the risk not sufficiently great to justify objections to vaccination.

CHAPTER V.

We have seen in the spread of the epidemic in Warrington, in 1892-93, what the factors were that tended to facilitate infection. We have also seen that when all these factors were taken into account, and proper measures were taken to meet them, then the epidemic ceased to spread, and gradually died away.

The first step in meeting an epidemic must, of necessity, be the recognition of the disease in as early a stage as is possible, before there is time for other persons to become infected. For many years, small-pox has only appeared in this country in isolated outbreaks, and at rare intervals, and there were many medical men who had never seen a case. Recently, however, the disease has appeared more frequently and in many centres, and it has thus become more familiar.

The chief difficulty lies in the mild cases. These may be mistaken for various other diseases, especially acne, measles, and chicken-pox.

(1) **Acne** may be distinguished from small-pox by the following points:—

- (*a*) Constitutional disturbance is present in small-pox, not in acne.
- (*b*) The position of the pustule. Acne favours the roots of the hair.
- (*c*) The fact that the acne spots may generally be seen in several stages, and some nearly always show the small points of comedones.

Other diseases which may be mistaken for small-pox in the early stages, are measles and chicken-pox.

(2) **As regards measles,** the likeness to small-pox lies both in the appearance and date of the eruption. Both rashes are papular and the colour is alike, and both appear on the fourth day of illness. The points of difference are that:—

- (*a*) In measles the papules are flat, whereas in small-pox they are rounded and "shotty."
- (*b*) In measles the papular character begins to subside at the end of about twelve hours, but in small-pox the shotty character goes on increasing, and, generally in forty-eight hours, passes into the vesicular, and thence into the pustular stage. Besides the rash, we have other symptoms which help us to a diagnosis, such as the coryza of measles, and the "fulness" of the eyes.

(3) **In chicken-pox,** the papular stage of the rash is very transient ; and the vesicles, which develop in a few hours, are clear on a slightly inflamed base, and are never hard and indurated. Different stages of the eruption may always in chicken-pox be seen at the same time, in the same region.

As distinguishing between the rashes of small-pox, measles, and chicken-pox, the age of the rash is important, as the appearance of the rash is different in all three at any time after twelve hours.

There may be difficulties arising also from the presence of initial rashes in small-pox, before the true rash appears. These are usually of an erythematous nature, and are comparatively rare.

Besides the failure on the part of a medical man to recognise small-pox, there is the consideration that if the case be mild, no doctor may be called to see the patient. In Warrington there were such cases—some where the patient continued at work with the rash out. There is no way of meeting the difficulty in such cases. They are not, however, very frequent, as in nearly all cases pain in the back is severe. In the case of the epidemic spreading, the public come to recognise the disease themselves, and then there is more likelihood of patients suspecting small-pox when it is not present, than allowing mild cases to pass unrecognised.

When the disease has been recognised, notification follows. There can be no two opinions about the necessity of this. It is incumbent that the householder should be responsible in this matter as well as the doctor, and rightly so. In all communities there are sure to be some people ready to conceal infection for one reason or another, and it is well that such should be prosecuted and punished.

After notification, the next step is the isolation of the patient. In the case of a highly infectious disease such as small-pox, this cannot except very rarely be carried out at all perfectly in the patient's home. The question thus becomes one of the removal of the patient to hospital.

After removal of the patient from home to the hospital, the house, bedding, and furniture must be disinfected by suitable means: burning sulphur, hot air or steam, washing with antiseptics, etc.

Besides removing the patient and disinfecting the house, etc., there is also the question of the patient's friends who may have been in contact with him. They should be quarantined for fourteen days, and should be re-vaccinated if that has not been already done. In the preliminary outbreak at Warrington, all the family were removed to hospital, including the mother, who was not attacked. There were no other friends. This is probably the reason why at this time the disease did not spread. In most cases it is of little use cautioning the people not to mix with others. In one instance in Warrington, one woman before her removal to hospital collected her friends for a farewell cup of tea with her.

Hospital provision.

It is necessary that at the beginning of an outbreak of small-pox there should be hospital accommodation ready. If not, most valuable time is lost and the disease given an opportunity for dissemination. The accommodation must also be reasonably ample for the population. If the outbreak does get any headway, then more and more hospital room will become necessary. If, on the other hand, the accommodation to begin with is sufficient, and if the other measures for prevention are equally efficient, then there is every probability that the disease will not spread. The question of hospital accommodation is one of cost. There can be no doubt as to what is the proper business course to adopt by communities with a view to epidemic disease, and to economy. It stands to reason that it is cheaper to insure against fire, accident, and other undesirable things, than to run the risk. In this case, also, it is the safer way.

Dr. SAVILL has calculated that the cost to Warrington of the epidemic of small-pox in 1892-93, amounted to over £20,000. There is no shadow of doubt that it would have been cheaper for Warrington to have provided against this outlay, by having sufficient hospital accommodation in the early stages of the epidemic, as by this means in all probability the spread of the disease would have been arrested, and the total cost very much diminished.

The amount of hospital accommodation which is usually considered sufficient for a community, is one bed for every 1,000 inhabitants. The calculation is of course based upon the average annual number of infectious cases occurring in the community.

Having a number of cases of small-pox removed and aggregated in one centre, it is necessary to guard against them there forming a focus for fresh spread of infection. For this reason, isolation must be very complete, and the movements of the staff and the coming of visitors strictly regulated. For the same reason, it is well to have the hospital removed from close proximity to other houses. This should be the case apart altogether from the question whether small-pox is spread by diffusion of its infection by atmospheric currents. This question, however, is very important, and the evidence in regard to it to be derived from the Warrington Epidemic of 1892-93 deserves to be fully gone into.

The question of aërial convection of small-pox.

Up till now, there has been no microbe discovered as the cause of small-pox; and although, doubtless, there is such a microbe, its life-history is altogether unknown. Whether it can be transferred by aërial currents, or whether its vitality is destroyed by the atmosphere, is a question that must be answered by what we may term circumstantial evidence. Of such evidence we have a fair amount in the case of the Warrington epidemic, and by a consideration of this evidence we get a good deal of light on the subject. Supposing a diffusion of small-pox takes place aërially, the spread of infection cannot be directly traced, and we can only claim this as one method after we have, with tolerable certainty, excluded other and usual modes of infection. We can only found conclusions upon a number of cases. Isolated cases are not sufficient to go upon. In an infected area, having excluded the usual methods of infection, (*a*) direct contact, and (*b*) conveyance of infection by intermediate means, such as third persons, clothing, etc., before concluding that transference by air took place, we should expect to find :—

(1) That in the area infected, the number of infections around the supposed centre would vary in

the different quarters in proportion to the number of days during which the wind blew from directions opposite to them.

(2) The number of cases would be inversely proportionate to the distances from the supposed centre.

In the Report, various tables are given ; also maps, and much information bearing on this question.

There were two centres which might be looked upon as likely to act in this way, in the Warrington epidemic.

(1) The Old Borough Fever Hospital in Aikin Street.

(2) The Hope Temporary Hospital in Dallam Lane.

I.—The Old Borough Fever Hospital as a supposed centre of aërial diffusion.

We may first mention certain points about the position of the hospital :—

" By far the most densely infected district of the whole town was a square-shaped area, containing Howard Street, Wakefield Street, and Guardian Street." This area is quite close to the Old Fever Hospital. " It, and not the Hospital itself, was the focus of the epidemic during August, September and October." In this area resided several cases, unisolated, which were the means of the high infection of the district. How this was so, is seen more clearly when we consider the second point.

There are three open spaces, close by the hospital, where the children played and the neighbours gossiped. By ordinary means, in this way, we find that infection was spread, and aërial convection as a causal agent is, so far, not required.

The Workhouse is next door to the hospital, separated only by a high wall.

Even allowing that the source of infection in all cases in the area mentioned could not be traced, we find difficulty in proving that aërial convection acted as a cause, for—

"(1) The numbers of infected houses do not work out in perfect keeping with a theory of proportionate distances from the hospital as a centre.

"(2) The largest proportion of infected houses is to be found in the 2-300 yards S.E. quadrant, not in the quadrant opposite to the prevailing winds, S.W. and S.E."

(3) The course of events in the Workhouse adjoining points to the great unlikelihood of there being any convection by aërial currents. The nearest buildings of the Workhouse and the hospital are 125 yards distant. In the Workhouse, six cases arose in the course of the epidemic. The first case had several

alternative sources of direct infection, and all the others were traceable to this one. Between August and December, there were 712 persons, of different ages and conditions, in the Workhouse, exposed to any aërial influences emanating from the hospital. Nevertheless, there were only .8 per cent. of them attacked (as compared with 1.2 per cent. of the whole town), and in all but one of them a clearly established direct source of infection was known to have existed. In the solitary exception, the first case, there existed several alternatives of infection in the usual way.

If, therefore, the hospital formed a centre for aërial spread, it is most remarkable that all these 706 persons should have escaped attack.

These persons were not all protected by re-vaccination as one might be ready to suppose. Before September 19th, when the small-pox cases were removed to Dallam Lane, only fifty-nine persons were so protected.

No other condition was present which would have prevented these persons from contracting the disease aërially, had the principle of aërial convection been in operation.

II. The New or Temporary Hospital (Hope Hospital) in Dallam Lane.

This was situated near the northern fringe of the populated part of the town. It was not cut off properly from outside communication. There were two ways of keeping up this means of communication, which served to permit the spread of infection by direct and indirect means. These were :—

(1) For two months after it was opened, that is, until the middle of November, the palings to the east side were not properly completed. Up till that time, people could talk through openings in the palings, and did so.

(2) During the whole time, the palings on the south side were quite low, and in January and March there was a large opening through which people could and did pass.

These two means of communication naturally lent themselves as openings for the transmission of infection and lessen the necessity of accounting for the spread of small-pox by aërial currents.

Besides these points there are others :—

(1) The staff slept at the old hospital and went backwards and forwards every day, mostly in a cab.

(2) Convalescent patients were engaged to assist the staff.

These two circumstances were owing to the urgent state of affairs and the large amount of accommodation suddenly required for cases.

(3) The patients' clothes were sent to be disinfected at the old hospital.

(4) Until November the same ambulance was used for small-pox and for scarlet-fever.

(5) Through an old disused window covered with tarpaulin, patients' friends communicated with those inside.

All these means together must be considered as tending very much to direct and indirect transmission of the disease.

When we come to consider the separate points in connection with supposed aërial spread we find :—

I.—Relation to prevailing winds.

The prevailing winds were S.E. and S.W. Instead of the maximum proportion of cases being in the quadrant opposite to this, the reverse is the case; the N.E. quadrant being the least with 6 per cent. of cases, and the S.E. quadrant the most with 14 per cent. "The number of infected houses is not, therefore, proportionate to the direction of the wind."

The force of the wind was moderate or light, except on three days.

II.—There were, as stated, many sources of direct spread of disease from the hospital.

(*a*) The movements of the staff, and the incomplete state of the palings surrounding the hospital.

(*b*) An open space beside the hospital was the resort for all the people in the neighbourhood, and for friends who wished to communicate with those inside.

(*c*) Cases of delayed isolation. One may be quoted :—

"Case 354, living in Owen Street, beside the hospital, developed the eruption about October 12. He was never isolated at all. His wife, who lived at home with him, daily went as waitress to the 'F———'s Arms,' in Dallam Lane, hard by, the chief resort of the Dallam forgemen. She waited on the visitors to this inn and looked after her unisolated husband during four weeks, up to November 9th, when she herself began to sicken of the malady, having in the meantime conveyed the disease to two of the inmates of the inn, and to an indefinite number of the Dallam forgemen, who were supposed also to be under the influence of aërial diffusion from their proximity to the hospital.

"During the three weeks ending November 19th, no fewer than forty-three of the Dallam forgemen developed the eruption."

(*d*) The gregarious habits of the inhabitants. "The children when not at school, or at play in the open places or streets, had the run of all the houses in the street."

(*e*) Unsuspected sources of direct infection from elsewhere.

III.—Incidence of small-pox in factories around the hospital. We may compare the cases in two of these.

(*a*) Dallam and Bewsey Forge, where there were many cases.

(*b*) Dallam Lane Brewery, where there were few cases.

Both these places are near the hospital, and any theory, such as aërial convection, applying to one, would apply to the other.

The first point to consider is whether we can ascertain or exclude infection by direct or mediate means.

At the Forge, we find that the sources of direct infection to the workmen were numerous.

(1) From the hospital itself. The hospital, as already shown, was not sufficiently cut off from communication with the outside. There were low palings and uncompleted palings separating it off from the open spaces near it, and by these means

people outside communicated with their friends or fellow-workmen inside. It was not until the first week in November that the barricades were placed across Dallam Lane. It was in the second week of November that the greatest number of cases occurred among the forgemen.

There was an entrance through which it was a common practice for workmen to pass in and out to work from Dallam Lane, directly beside the entrance to the hospital. Many cases came under Dr. SAVILL'S notice where workmen contracted the disease by communicating with their fellow-workmen in hospital.

(2) Other sources of direct infection were:—

Previous cases in their own homes;
Unisolated cases living near them at home whom they visited;
Unisolated cases in their fellow-workmen's homes, or other means of mediate infection by third persons;
Visits to infected public-houses or shops.

Some cases are quoted in the Report illustrative of direct infection, and are good examples of how small-pox may be spread.

"M. E., developed the rash on August 17th; remained at home one month. During all that time, her father and one of her brothers worked in the puddling mill, and another brother worked as a labourer all over the Forge. There was no disinfection after she was removed on September 9th, for two weeks.

A man, H., developed the rash on September 16th, and was never removed. His next-door neighbour, who came to see him frequently, worked in the bar-mills all the time, and finally took the disease.

A man, S., developed the rash on October 7th, and was unisolated till October 21st. A man, M., living in the same house, worked from October 7th to the 17th at the foundry, when he finally developed the eruption himself.

Walter R., developed the rash on November 10th, and was never isolated, but went about the house all the time. His father and brother worked about in different parts of the Bewsey Forge all the while.

A man, R., developed the rash on November 9th; he was never isolated. His father and brother worked at the forge all the time, until the father developed the rash on November 29th.

Thomas P., developed the disease on September 20th. He was the fifth person to be attacked at the Dallam and Bewsey Forge, but the real source of his infection was his mother-in-law, Mrs. M., who used to come in and out at the same time that she was nursing the C———'s, (Cases 57, 98, and 112).

In connection with the workers at the Dallam and Bewsey Forge, " there are only two circumstances which seem to speak in favour of the possibility of spread by aërial currents, viz. :—

"(1) The high attack rate at the Forge, adjacent to the Temporary Hospital.

"(2) The percentage of each department of the works, varying in some degree with the distance from the hospital."

On the other hand, both these facts are otherwise explicable, the hospital being a source of direct infection on both its east and west sides, and through the gate of the works; and, also, there was direct and indirect infection through shops and public-houses, notably the " F——— Arms."

We come next to the incidence at the Brewery, (Walker's). Here there were 364 persons employed, amongst whom only four cases of small-pox developed. All these four cases are perfectly well explained by direct infection. Now, if there had been any infection by aërial currents, surely a case would have occurred from this source at the Brewery among 364 persons. The reason why there were so few cases at the Brewery, was that they were not exposed to such potent sources of direct infection as the workers at the Forge, for—

(1) The entrance was not, like that of the Forge, in direct continuity with that of the hospital.

(2) The brewers did not have unisolated cases of small-pox at home, or relatives of small-pox cases among them at work.

(3) Nor did they communicate with patients in hospital.

(4) Nor did they require to go to public-houses for beer.

The facts relating to other works, all tend in the same direction. At a fustian-cutting shop, there were many cases early in 1893, "but not a single case arose amongst them in the last three months of 1892, when the hospital was full to overflowing, and the prevailing wind blew their way."

In all the works, there is a remarkable absence of unexplained cases of infection.

All these facts point to the usual methods of infection being direct and mediate, and go to show that aërial currents took little part in the spread of the epidemic, and it is quite unnecessary to assume any such theory as an explanation.

CHAPTER VI.

Relation of Small-pox to general Social and Hygienic conditions.

(1) Housing and overcrowding.

There is no doubt that where there is overcrowding, there must be more opportunity for infection to spread. If a case remains without being recognised, or if isolation is delayed from any cause, there is a likelihood of more persons being attacked when there are more persons living in the house. Still more especially when the house is small. Probably also a larger proportion of the persons in the house will be attacked. It is also evident that any extra number of cases in a house, means so many fresh centres of infection.

The number of persons per house in Warrington, taking the town as a whole, was 5.4 as compared with 5.8 per house in the infected houses. This does not show a great difference.

There is also the overcrowding to be considered, taking the number of inhabitants per acre. In Warrington, the houses invaded by small-pox were practically all of one type, and accordingly we can gather no information on this head. Apart from this, any result by comparing numbers would be considerably influenced by other factors, of which no reckoning can be made—ignorance, vice, dirt, and destitution, which are more evident in the more densely populated parts of a town.

(2) Occupation.

There is not much to show that small-pox has any predilection for any one occupation. The Report shows that in the industry of fustian or velvet cutting, the disease once introduced into any room, spread with greater rapidity than in other occupations. This was probably owing to the occupation being a dusty one. In some shops, all the workers escaped, whilst in others the attack-rate was heavy.

(3) Social conditions.

It would appear that the upper and middle classes largely escaped infection. The reasons would be that—

(1) The habits of these classes are more cleanly.

(2) They are more generally re-vaccinated.

(3) There is not the same amount of close commingling of separate families and households.

Among the lower classes there are more intimate relations, and more coming and going between different households, and this largely accounts for the spread of infection among them.

(4) The houses of the upper classes are more isolated than those of the lower.

The following are the percentages attacked in various classes of houses :—

HOUSES RATED AT		
£8 and under.	More than £8 and less than £16.	£16 and over.
5·99	1.93	1.23

(4) **General habits.**

A large part of the population is of a floating character, and there is no doubt that this fact lent itself to the introduction of infection into the town, and the very origin of the epidemic was a case among this class.

The habits of the people, in the way of coming and going into one anothers' houses, had, as we have seen, a great effect on the spread of infection. The same may be said of the resorting to the open spaces or "fields."

As regards intemperance, there was in Warrington a large amount of alcohol consumed, but there is no particular connection shown in the Report between intemperance and incidence of small-pox.

(5) **Sewage and Disposal of Refuse.**

Not knowing the *contagium* of small-pox, nor the class of organism causing it, it would be something to go upon if we found any relation between small-pox and any of the means of disposing of waste and refuse. Such, however, we do not find—at any rate, in this epidemic of 1892-93. In Warrington at that time there were only 400 waterclosets, and any faults in the system of sewers would accordingly be minimised. In any case, investigation showed no apparent connection between the sewerage system and the spread of the epidemic.

The same has to be said of the pail system for the disposal of excreta, upon which 9,000 houses were dependent.

As regards the removal of ashes and other solid refuse, no relation to the spread of the epidemic could be shown. There were seventy-five men employed in removing ashes and solid refuse. Of these only one was attacked by small-pox, and he had been, for a few weeks preceding his attack, employed removing cases of small-pox in the ambulance, and also removing clothes for disinfecting.

The general result of enquiry is to show that the disposal of refuse, excreta, and waste by sewers or other methods, had no influence over the spread of the infection of small-pox in this epidemic.

(6) **Water and food-supply.**

There was nothing to show that either water, milk or other food had anything to do with the epidemic except in the case of persons conveying food also conveying infection.

(7) **The influence of weather.**

Dr. SAVILL, in the Report, says: "I have failed to note any practical connection between the state of the weather and the small-pox epidemic in Warrington in 1892."

CONCLUSIONS.

From a general survey of all the facts presented to us in this epidemic, certain points stand out very clearly:—

(1) Small-pox spreads mainly along the lines of ordinary human intercourse. An individual suffering from the disease gives it to those coming in contact

with him; or a third party conveys the infection from one patient to another; or the infection is conveyed by means of articles which have been in contact with a person suffering from the disease.

(2) Amongst unprotected susceptible persons, the disease spreads easily. It is highly infectious.

(3) When unmodified it is a very dangerous disease, with a high mortality.

(4) It does not spread to any appreciable extent by means of atmospheric influences, and accordingly an epidemic is very amenable to measures of isolation and quarantine; but these measures are rendered of less effect by the fact that in its early stages, and especially in modified mild cases, the disease is apt to be overlooked, being mistaken for other diseases, especially acne, measles, and chicken-pox.

(5) Vaccination in infancy followed by re-vaccination in the second decade of life renders an individual practically immune.

(6) Vaccination, when followed by small-pox anytime within forty years, modifies the disease, causing it to be less severe and less frequently fatal.

(7) In the face of a rising epidemic, wholesale re-vaccination rapidly causes the epidemic to decline and finally to die away.

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